

A LANGUAGE USE PERSPECTIVE ON THE DESIGN OF HUMAN-COMPUTER INTERACTION

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ABSTRACT. Clark (1996) has identified common ground—information we take to be shared with others—as an indispensable requisite for everything people do with each other where language use or, more definitively, a collaborative use of meaning and understanding is involved. In interactive software development, though, theory and practice have placed little emphasis on the role and importance of this crucial aspect of cognition in user interactions, with the result that user interface and interaction designs are typically impoverished in ways they need not be. In this paper, the basic features of a language use approach to human-computer interaction are outlined, and a range of both noncomputational and computational implications for the design of interactive systems is examined. In particular, human-computer interaction is recast as a genuine instance of language use between the user and the system designer and, in a second layer, as a joint activity in which the system and the user are participants. In this view, principled interaction design is authorship that promotes common ground with the user at all times in all layers through noncomputational and/or computational means. Noncomputational means facilitate the user's development and maintenance of common ground with the author's design through passive and semipassive mechanisms that may also depend on user initiative. Computational means focus on actively maintaining a system-side image of common ground and using this to inform aspects of the system's interaction behavior. Key issues in computing common ground include representing and verifying what the user does and does not know, identifying and using conventions, and solving coordination problems posed by the user. Ways that both noncomputational and computationally based language use approaches to human-computer interaction designs can better support user comprehension and performance through the promotion and use of common ground, and cognitive issues these approaches address, are discussed.

1 Introduction

Motivated by a continuing effort to appreciate ways in which software user interfaces can be better made to support users, this short paper examines at a high level how and why the study of language use is theoretically relevant to the design of human-computer interaction.

At its heart, the study of language use is concerned with collaborations where one person's meaning and another's understanding are essential to carrying out what they are doing together. Meaning and understanding are conveyed through the use of signals, and any device that can serve this purpose well, no matter if it is a gesture, a sign, or an utterance, amounts to a use of language. (Think of the adage "a picture is worth a thousand words.") Arguably, people's language use skills—their complementary abilities to devise ways to indicate their intentions and to successfully resolve the indications of others—are their most fundamental resource in all activities that require collaboration.

Observations such as the foregoing about language use have direct implications for human-computer interaction. Although computers are far from the equivalent of people, people nevertheless use them to do all sorts of things that would be difficult at best to do on one's own. This use has the distinct character of a collaboration. People interact with software through user interfaces that require them to understand their role in the task and that constrain their goals and demand their cooperation in the coordination of a range of participatory actions.

But user interfaces are not devised by computers, of course. They are devised by people. As Terry Windograd noted in an interview published in Preece, et al. (1994), "everything that is in [a] computer came from somebody in some context with some purpose and some meaning." The implication is that the design of human-computer interaction is fundamentally a representation problem that involves the designer's meaning and the user's understanding.

The broader implication is that all principles of language use are important in human-computer interaction. In this paper, it is argued that they are the proper basis of a principled framework for interaction designs.

2 What is language use?

Herbert Clark (1996) characterizes the study of language use not as a science of the structure of language but instead as a cognitive and social science that is centrally concerned with the notions of speaker's meaning and addressee's understanding. In this view, all instances of language use are instances of two or more participants acting jointly in one setting or another, though not necessarily at the same time, who jointly coordinate individual cognitive, physical, and perceptual actions as needed to accomplish a social purpose they share. The setting in which a particular instance of language use occurs determines how these joint actions are coordinated and what skills are needed. Face-to-face settings are the most basic and written settings are perhaps the most demanding. Language use also often involves more than one conceptual domain of action. These domains are called layers and are identified by references to persons and/or settings, and possibly other matters, that are not necessarily present in the initial layer of action.

Language use always serves people's larger collaborative purposes—purposes that are met and carried out socially in their joint activities. Every instance of language use, though, is itself an act of collaboration. Signals are presented with the intention of conveying meaning. But meaning can only be understood with an addressee's participation. By taking up a signal and grasping its sense in context, addressees make the action behind the signal's presentation a meaningful and complete joint action. The principles at work in this process are the primary concern of language use studies.

Thus, meaning and understanding are central, and whenever these notions are involved, even wholly nonlinguistic collaborations between people should be readily identified as instances of language use. Wholly essential for meaning and

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understanding, though, is the notion of common ground, which Clark identifies as an indispensable requisite in all things people undertake to do with each other.

2.1 What is common ground?

Common ground is essentially a specific kind of shared knowledge. More precisely, it is knowledge that people take to be held in common on the basis of shared information. People try to justify and use common ground by presenting what they believe is an adequate shared basis for it. In general, all signals, be they words, images, or something else, function as shared information when they are presented and perceived. Suppose that two people have agreed to go to lunch at noon and one shows the other that it is now just past twelve. When the time is presented, it is a signal that becomes shared information. What is meant and understood by it, that they have agreed to go to lunch now, is knowledge that resides in their common ground on the basis of their earlier agreement. Presenting the time both justifies and makes use of this common ground by referring to their previous agreement concerning lunch at noon and indicating that it is time to go.

Common ground is built up moment-by-moment over a lifetime of joint activities and experience and presupposes certain cognitive processes (most notably, ordinary perceptual skills, the workings of short and long term memory, and mundane reasoning abilities). Every event that openly takes place and is mutually attended to in a joint activity immediately becomes a piece of knowledge in its participants' common ground. Ordinarily, this includes all of the shared bases people use with each other and, just as importantly, most of the inferences each would normally make in context. Clark argues that people conceptually divide their common ground in joint activities into at least three parts: first, the common ground they bring to the joint activity; second, an idea of the joint activity's current state; and third, a record of what has been done so far. People naturally keep track of this information in one form or another, but just as importantly, they expect their counterparts to do very much the same.

2.2 Coordination in language use

Common ground makes it possible for people to cooperatively orient each other's cognition with signals. To direct one person's understanding to what another means by a particular signal requires each individual to coordinate a corresponding set of interdependent physical, perceptual, and cognitive actions with his or her counterpart. This coordinated effort is what makes each instance of language use a joint action.

Clark characterizes joint actions involving meaning and understanding as coordination problems that people, in most instances of language use, pose for each other and then immediately work together to solve. To be efficient, certain principles apply. Among these are that first, a straightforward solution should already be in mind when the problem is posed. Second, all of the information needed to reach the solution, given what is common ground, should be shared in the problem's posing (this information functions as a coordination device). And third, this solution should be one that is readily and unambiguously apparent to everyone in context. Respectively, these are premises of solvability, sufficiency, and joint salience. Experience motivates people

to expect these premises to be met as they go about coordinating their joint actions; otherwise, a larger effort is always needed to accomplish the same thing.

Working out coordination problems is a dominant part of people's language use skills. In choosing the right basis to use as a coordination device, joint salience is usually the most important consideration. Capitalizing on this aspect of people's attention in context greatly increases the likelihood of their finding the intended solution. Two important sources of coordination devices that readily meet this test are external representations and conventions. External representations are simply elements of the physical situation in a setting of language use that can be used to represent parts of the joint activity taking place there. Not all external representations have the same properties and advantages, but they generally make superior coordination devices because of their perceptual immediacy and their inherent significance in the common ground of the moment. Conventions are representations of standing solutions to frequently occurring coordination problems, and therein lies their value: they are successful and familiar regularities of action. When a convention is signaled and recognized as a coordination device, addressees usually know instantly how to proceed. Conventions and systems of conventions are preeminently useful for purposes of language use. Clark notes that, "Languages like English are conventional signaling systems par excellence." Conventions and external representations are often found together. In joint activities that take place in written settings, for instance, the media itself is an external representation of the activity, and its elements serve as a continuous stream of conventional coordination devices (text, layout, etc.) that addressees use to complete most of the joint actions the writer has begun.

3 Language use in human-computer interaction

The basic claim of this paper is that human-computer interaction is, in fact, a genuine instance of language use. This is the case largely because of the nature of its supporting media: software user interfaces are not only design artifacts (i.e., products of human design) but are also a means for carrying out a class of joint activities (doing computationally based tasks) in which all principles of language use apply, and whose primary participants are people acting as themselves in the roles of designer and user. In contrast, the notion of interacting with the computer (human-computer interaction per se) is simply a secondary layer of action on top of this primary one (more on this below).

The joint activity between people defined by human-computer interaction is made up of joint actions that arise from the coordination of individual cognitive, physical, and perceptual actions on the part of both the designer and the user, albeit across time. These joint actions implicitly depend on the function of common ground and always involve the designer's meaning and the user's understanding. Put another way, a software user interface presents a designer's notion of how a particular computational task can be organized and carried out. When a user takes up the task, part of what he or she faces is the job of solving a substantial array of coordination problems the designer has posed. Every aspect of the presentation is available to be used as a coordination device, and each solution the user correctly converges on

makes joint a corresponding set of pre-coordinated actions the designer has initiated.

3.1 Comparing written settings

Because the designer's conception has been worked out and produced in advance of its presentation, the joint activity that takes place in the primary layer of human-computer interaction must rightly be characterized as one that takes place in a written setting. In contrast to more conventional written media such as that of a book, the scene and medium of this written setting are those of a computer's interactive display. All written presentations share certain basic characteristics, but the written media of human-computer interaction differs from conventional written media in several important ways.

3.1.1 Layers

First, unlike the second layer of action that is ordinarily presented in a book or magazine, wherein the reader remains in a written setting but participates in the imagining of a story or the domain of an essay, the second layer of action in human-computer interaction, perhaps surprisingly, places the user in a face-to-face setting. Here, the user is expected to interact with the computer to carry out the joint activity implicit in the software task, as if the computer and not the designer were the user's real counterpart. This shift of setting and participants between layers naturally makes correspondingly different demands on the user's language use skills and also has potentially damaging consequences for the function of common ground.

3.1.2 Presentation properties

A second key difference between conventional written media and that of human-computer interaction can be found in the organization and expectations of the latter's presentation, which is nonlinear and deliberately opportunistic. This is decidedly different from the linear presentation that is the encouraged convention in most other written settings. Instead, in human-computer interaction, the user has opportunistic control of the joint activity. Inevitably, this leads to a contingent branching of focus that no nontrivial design can fully anticipate for the user. Hence, when designs rely on dependent concepts for the solution of widely divergent goals, as they sometimes must, users understandably may not know what to do next through no fault of their own. Users often have little recourse, though, but to depend on the designer, in posing coordination problems, to honor their natural expectations of solvability, sufficiency, and joint salience.

Several other presentation properties are worth highlighting at this point. Human-computer interaction relies on a language of coordination devices that is made up of a variety of linguistic and nonlinguistic signals including elements of natural language, visual artifacts, and behaviors (i.e., actions and procedures). Many of these presentation elements, in the modern culture of computer literacy, are rightly intended to be construed as conventions. The presentation also serves in part as an external representation of the joint activity. This aspect of a software user interface is usually intended to function as a manipulable model of the task at hand, but does not always fully indicate the task's status. For instance, actions that take place in the external representation are often evanescent to the extent that a user may have to return to an earlier procedure to

confirm the outcome of a previous event. And while the external representation is accessible to both the user and the system, it is mostly unused by the system as a means for justifying common ground in the second layer of action.

3.1.3 Common ground

Common ground turns out to be built differently in each of the first two layers of human-computer interaction, and this proves to be a third important way user interfaces understood as written media differ in their use from conventional written presentations. For both the designer and the user, finding common ground is an intuitive prerequisite for the conduct of their joint activity. More often than not, a presentation's use of various sorts of display conventions will be enough to get this process started. Unfortunately, though, because software user interfaces are conventionally organized as nonlinear presentations, the designer's control over the process of building a complete body of common ground with the user in the planned manner of a linear presentation is sacrificed. Linearly organized presentations in conventional written media have an important strength: they naturally correspond to what Clark calls the third part of common ground in joint activities, i.e., a record of what has been done so far. This correspondence permits addressees to use such presentations to their advantage; they are, for instance, intuitively indexed and readily open to review when misunderstandings or questions arise. However, in the written setting of human-computer interaction (specifically, in its first layer), the designer can only build common ground with the user in an irregular manner. The reason for this limitation is the opportunistic nature of the presentation. That is, opportunities for the designer to informally promote all of the common ground the user will need to efficiently coordinate any part of the joint activity published in the design are effectively contingent on what the user chooses to do. For users, a further difficulty with written presentations of this sort of lies in their inherent lack of correspondence with the third part of common ground and the advantages that would attend. As a consequence, over repeated episodes of use, software users often develop a palpable sense of where their common ground with a design is missing and will even look for it on occasion unless the effort proves to be too costly.

Building common ground with the designer in a user interfaces's first layer of action is, of course, wholly relevant to working directly with the operation of the computer in the second layer. By design, second layer interactions are in many respects intended to resemble the regular conduct of joint activities in face-to-face settings, albeit with a sophisticated information processing machine. Ordinarily in face-to-face interactions, people expect each other to keep track of what they are doing together as part of a transparent exercise of their mundane language use skills. Indeed, people nominally do this in any activity they undertake, even if others are not involved. Accordingly, it can readily be argued that the knowledge people accumulate and are able to justify in all of their undertakings corresponds structurally to Clark's three parts of common ground: knowledge initially held about an activity at its start, knowledge of the activity's current state, and knowledge of what has taken place so far.

When this kind of knowledge is acquired in an interactive setting with other people, it functions as common ground

whenever shared informational bases exist to justify it as such. When it is acquired in another sort of interactive setting, one where the activity involves only components of the environment that maintain no such knowledge, it can only be construed pragmatically as an individual's lone conception of the activity. The knowledge users acquire in the second layer of human-computer interaction, though, falls somewhere in between these two extremes—for the most part, it is only the user's conception of the activity, but in certain ways, it is also part common ground. Put more explicitly, in face-to-face interactions with computers, users regularly keep track of contingent interaction knowledge corresponding to the three parts of common ground as well as any informational bases that may be needed to justify it. Throughout the course of the interaction, the software keeps track of some of this same knowledge and shares corresponding informational bases in limited, ad hoc ways (with undo mechanisms, for instance, and other kinds of interaction histories). Contingent interaction knowledge the software fails to be able to justify and use, though, cannot be construed as common ground in the setting nor the layer. Failures of this sort have the effect of withering most expectations of the computer's capacity to keep track of the joint activity as another person would. As a consequence, many of the user's face-to-face language use skills go largely unused.

3.2 Design challenges

As the foregoing discussion has attempted to illustrate, when the normal, linearly accumulative function of common ground in a language use setting is impaired, people are naturally forced to work harder cognitively to accomplish their goals. Unfortunately, this is the case in the settings of both layers of human-computer interaction. Since opportunistic interaction inherently builds incomplete common ground in the first layer of an interaction design, straightforward design strategies that reward user initiative with, for instance, inexpensive, well indexed, at hand access to missing knowledge when discrepancies are encountered and/or simple, unobtrusive ways to document procedures in context are certainly worth considering. A more difficult challenge obtains in the design of second layer interactions. Here, the clear need is to devise further reliable ways for user interfaces to accumulate, justify, and use additional contingent interaction knowledge as it develops in a given instance of human-computer interaction. With well designed access to second layer common ground, users should be able to make greater and more efficient use of their face-to-face language use skills and the cognitive resources these skills support.

4 Research approaches

As an adjunct to the short review of basic design challenges for language use in human-computer interaction presented at the end of the previous section, the remainder of this paper briefly describes two fundamental approaches for design research in this area, one targeted principally at issues of usability and the other at the problem of face-to-face interactions with user interfaces

4.1 The noncomputational approach

The essential thrust of this approach is to revisit the notion of user-centered design (Norman and Draper, 1986) through the lens of language use principles. Common ground in this view is seen as a *sine qua non* for usability. Strategies worth investigating under this heading include design reviews that evaluate both the presentation language as a set of shared informational bases and the interaction design as a set of coordination problems. Such reviews should focus on issues of intended meaning and the user's expectations of solvability, sufficiency, and joint salience. Certain legacy strategies that deserve renewed investigation as user initiated means for addressing the inherent first layer difficulty of building adequate common ground also fall into this approach. These strategies include the design of robust, low cost, point-of-use reference, tutorial, annotation, and interaction history mechanisms.

4.2 The computational approach

The long range goal of this approach is to share the user's cognitive load and promote the use of face-to-face language use skills in the second layer of interaction designs. Although many behaviors exhibited by user interfaces can be easily misconstrued as evidence of regular maintenance of common ground by a computer (e.g., various reflexive mechanisms, corrective and alerting behaviors, and history mechanisms in general), fully functional common ground between users and computers can only arise when the computer maintains a system-side representation of the three parts of common ground in user interactions and can justify and use this knowledge on the basis of shared information to advance the joint activity in reliable and productive ways. Ultimately, this is a design problem for artificial intelligence techniques (Brock and Trafton, 1999). Most aspects of reasoning about common ground are computationally challenging. Significant computational goals include representing and verifying what the user does and does not know about the joint activity, perceiving and solving coordination problems posed by user, and identifying and using conventions (Alterman and Garland, 2001). Design issues raised by these goals include matters of system initiative, appropriate knowledge boundaries (reasoning about content vs. reasoning about functionality) and the design of face-to-face interactions about interactions, which are necessary to more fully support users' language use skills in second layer transactions.

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A Language Use Perspective on the Design of Human-Computer Interaction

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Motivating question



How can user interfaces better support users?

Observations



- People use language (in all senses where meaning and understanding are needed) to do things with each other, e.g., to collaborate
- People's language use skills are their most fundamental resource in all interaction contexts involving meaning and understanding
- Although people interact with computers to do things, people are also the authors of human-computer interaction designs

Implications



- The design of human-computer interaction is a representation problem that involves the designer's meaning and the user's understanding
- Accommodating the principles of how people use language is relevant as a framework for the design of human-computer interaction

What is language use?



Language use

- allows people to carry out joint activities
- is a collaborative form of joint action built on individual actions
- always involves at least one person's meaning and another's understanding
- depends on representation, i.e, the use of signs and symbols as signals
- is a cognitive science and a social science
- is not the study of linguistics

Principles of language use



- Language is used to carry out joint activities
- Language use is defined by joint actions that arise from the coordination of cognitive, physical, and perceptual actions people (e.g., speaker and addressee) carry out as individuals
- A joint activity's setting determines how these joint actions are coordinated and what skills are needed
- Face-to-face settings are the most basic, written settings are the most demanding
- Meaning and understanding in joint actions requires common ground

What is common ground?



Common ground

- is *knowledge people take to be held in common on the basis of shared information*
- People try to justify and use common ground by presenting what they believe are shared bases for it
- Signals in use among people (e.g., words and gestures) are examples of such shared bases of information
- Common ground presupposes certain cognitive processes and is built up moment-by-moment over a lifetime of joint activities and experience

Three parts of common ground in joint activities:

- knowledge initially taken to be held in common
- knowledge of the joint activity's current state
- knowledge of what has openly taken place so far

More principles of language use



- People expect each other to accrue and use knowledge and information corresponding to common ground
- Each joint action involving meaning and understanding is a coordination problem people must try to solve together
- When people pose coordination problems to each other, they usually have specific solutions in mind and can be expected to present *the most salient and sufficient bases with respect to their common ground* as coordination devices for indicating these solutions
- External representations and conventions are excellent sources of coordination devices
- Language use frequently involves more than one conceptual layer of activity

Language use in human-computer interaction



Claim: human-computer interaction is a *genuine instance of language use*

- It is a layered joint activity (doing a computational task) in which all principles of language use apply, whose primary participants are the designer and the user in these roles
- The joint actions that make up this joint activity arise from the coordination of individual cognitive, physical, and perceptual actions
- These joint actions depend on common ground and always involve the designer's meaning and the user's understanding
- It takes place in a particular type of written setting whose scene and medium are a pre-planned, interactive computational presentation

Comparing written settings



Human-computer interaction differs from a conventional written setting:

- Second layer of action takes place in a face-to-face setting
- Presentation is nonlinear and deliberately opportunistic
- Common ground is built differently in both first and second layers
- External representation of joint activity is dynamic, partly evanescent

	Book	Human-computer interaction
Joint activity	Relating subject matter of book	Relating and doing computational task
Setting	Written in all layers	Written in 1 st layer, face-to-face in 2 nd
Presentation	Linear, static	Nonlinear, opportunistic
Participants	Writer, reader; pos. others in other layers	Designer, user; computer in 2 nd layer
First layer	Writer, reader as themselves	Designer, user as themselves
Second layer	Writer, reader immersed in subject matter	User and computer carrying out task
Common ground - initial	Conventional literacy, introduction	Computer literacy, tutorial
Common ground - state	Corresponds to bookmark	May correspond to state of display
Common ground - events	Corresponds to previous portion of book	Corresponds to interaction history
Meaning & understanding	Writer poses coordination problems	Designer poses coordination problems
Coordination devices	Elements on page	Elements and behavior of display
External representation	Printed matter	Dynamic, partly evanescent display
Conventions	Written language, organization	Actions, display elements, input devices

Layers in human-computer interaction



Human-computer interaction has two principal layers of activity

First layer:

- Designer and user carry out a joint activity whose purpose is to carry out a computational task *as themselves* in these roles
- Takes place in a *written setting*

Second layer:

- User interacts with the computer to carry out the same joint activity *as if the computer were the user's counterpart*
- Takes place in a *face-to-face setting*
- Each layer makes different demands of the user's language use skills

Presentation properties of human-computer interaction



The presentation:

- serves as an external representation of the joint activity
- poses a fixed set of coordination problems (joint actions) whose solution depends on the user's participation (i.e., comprehension and physical interaction)
- uses a language of coordination devices made up of a variety of linguistic and nonlinguistic signals, including elements of natural language, visual artifacts, and behaviors (i.e., actions and procedures)
- depends on many elements of the presentation language to be construed as conventions

Note: users depend on the designer, in posing coordination problems for carrying out the joint activity, to honor their expectations of salience, sufficiency, and solvability

Additional presentation properties of human-computer interaction



Presentation is nonlinear and opportunistic:

- User has opportunistic control of joint activity
- Opportunistic design gives direct, nonlinear access to starting points for carrying out goals and subgoals
- Elements of the joint activity anticipated by the design are presented as planned, linear interaction sequences
- Branching afforded by design inherently leads to contingent paths among planned interaction sequences

Presentation's external representation of the joint activity:

- Serves in part as a manipulable model of the joint activity, but does not always indicate its state
- Is accessible to both the user and the system but is mostly unused by the system to justify common ground
- Actions in the external representation are often evanescent

Knowledge people accumulate about interactions



Claim: In any interactive activity, the knowledge people accumulate and are able to justify corresponds structurally to the three parts of common ground:

- knowledge initially held about the activity
- knowledge of the activity's current state
- Knowledge of what has taken place in the activity

Knowledge of an activity:

- is common ground when the interaction takes place between people and shared informational bases exist to justify it as common ground
- is only an individual's conception of the activity when the interaction takes place with elements of the environment that accrue no such knowledge
- is part common ground and part individual conception in human-computer interaction

Common ground in the *first layer* of human-computer interaction



In a nonlinear presentation:

- Both the designer and the user strive to find and build common ground, but...
- The designer's control over the process of building a complete body of common ground with the user in the planned manner of a linear presentation is sacrificed
- The user's common ground with the designer builds contingently on the basis of
 - Opportunistically becoming familiar with the presentation language
 - Opportunistically solving coordination problems posed in the interaction design
- Over time, the user develops a sense of where common ground is missing and will often look for it unless the effort proves to be too expensive

Common ground in the *second layer* of human-computer interaction



When the user engages the computer through a software user interface:

- The interaction is designed to resemble a joint activity in a face-to-face setting
- The user actively keeps track of contingent interaction knowledge corresponding to three parts of common ground as well as informational bases to justify it
- At most, software keeps track of some of the same knowledge and shares informational bases in limited, ad hoc ways, such as undo mechanisms and other kinds of interaction histories
- Contingent interaction knowledge the software fails to be able to justify and use cannot be construed as common ground in the setting nor the layer
- User's face-to-face language use skills go largely unused

Improving language use in human-computer interaction



Claim: when the normal function of common ground in a language use setting is impaired, people are forced to work harder cognitively to accomplish their goals

Since opportunistic interaction inherently builds incomplete common ground in the *first layer* of an interaction design,

- users need inexpensive access to missing knowledge when they encounter discrepancies in their common ground
- users need inexpensive ways to off load and/or confirm their understanding

Reliable use of additional contingent interaction knowledge by the user interface in the *second layer* of human-computer interaction can give users opportunities to:

- make increased use of their face-to-face language use skills
- make more efficient use of their cognitive resources

Complementary approaches to language use in human-computer interaction



Noncomputational approach

- Common ground between user and designer in their roles as participants in the joint activity of doing a computational task is a sine qua non for usability
- This is essentially user-centered design viewed from a language use perspective
- Empowers user; applies mostly to first layer concerns

Computational approach

- Many, if not most, aspects of reasoning about common ground are computationally challenging
- Ultimately, this is a design problem for artificial intelligence techniques
- Potential for sharing user's cognitive load and capitalizing on user's language use skills in revisions and repairs

Noncomputational approach



Goal: to improve usability in fixed interaction designs through the application of principles of language use

As part of the usability engineering process,

- evaluate the presentation language as a set of shared informational bases for knowledge about the design that should be taken as common ground for the joint activity:
 - Look for shared bases that are ambiguous, obscure, or indicate knowledge that should not be common ground
 - Evaluate use of convention and novelty
- evaluate the interaction design as a set of coordination problems and look for violations of language use principles:
 - Are expectations of salience, sufficiency, and solvability met?
 - Do interaction results confirm user's intentions?
 - Can misunderstandings arise due to timing or coordination?

More on Noncomputational Approach



Provide enhanced, interactively inexpensive ways for users to find and reinforce common ground on their own such as:

- point of use reference and annotation mechanisms that take user to relevant entries in glossaries, procedural descriptions and limitations, tutorials, personal notes, etc.
 - Dowdy but fertile area for additional interaction design research
 - Minimize cost of interruption in terms of leaving, using, and returning to reference, and returning to point of use
- full interaction history mechanisms that can be used and reviewed
 - Interaction histories correspond to third part of common ground in joint activities
 - Interaction design and use issues similar to those above apply

Computational approach



Goal: to share user's cognitive load and promote user's language use skills in the face-to-face setting (second layer) of human-computer interaction

Note that many behaviors in user interface can be confused with maintenance of common ground by computer

- Reactive behaviors (e.g., passive interactions with cursor)
- Alerting and corrective behaviors (e.g., spelling, grammar)
- History mechanisms (e.g., undo, recent documents, etc.)

Functional common ground between the user and the computer can only arise when the computer:

- maintains a system-side representation of the three parts of common ground in user interactions
- can justify this knowledge on the basis of shared information
- can use this knowledge to advance the joint activity

More on computational approach



Challenges and issues...

- Significant computational goals:
 - Representing and verifying what the user does and does not know about the joint activity
 - Perceiving and solving coordination problems posed by user
 - Identifying and using conventions
- Issues:
 - Designing face-to-face interactions about interactions to capitalize on user's language use skills
 - What knowledge is appropriate for common ground? (reasoning about content vs. reasoning about functionality)
 - Shared knowledge the system can justify can also be used as a basis for initiative - when is initiative appropriate?

Relevant work at NRL



- Collaborative Engineering Environments (ONR)
 - Design studies (with H. Ng, NRL)
 - WARCON CEE IPT member (ONR)
 - Language Use Principles for Developing Collaborative Environments (Brock, 2000, unpublished paper)
- Task model tracing (NRL, ONR)
 - ACT-R model of resource allocation task used to trace user interactions and compute common ground
 - A Language Use Approach to Human-Computer Interaction (Brock, 2001)
- Alerting and Interruption (ONR)
 - Multimodal interface studies (with J. Ballas, NRL)
 - Interruption studies (with G. Trafton, NRL)

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